Claims

1. A method of in situ electroremediation of soil material, the method comprising

- placing a plurality of electrodes in the soil at respective positions in a land area;
- supplying electric current through the electrodes;
- obtaining information indicative of electrical resistances of paths from surfaces of respective ones of the electrodes into the soil;
- detecting whether increases occurs in the electrical resistances;
- temporarily cutting down electrical current at least through a particular electrode in the path from which an increase of the electrical resistance is detected, to a stepped down level, in response to said detection.

2. A method according to Claim 1, wherein voltage differences are applied between electrodes from a first group and electrodes from a second group, said monitoring comprising measuring overall resistance information indicative of resistances from respective electrodes of the first group to one or more neighboring electrodes from the second group, said overall resistance information being used to detect the resistance increases, the method comprising eliminating at least part of an effect of soil resistivity on said detecting.

3. A method according to Claim 2, comprising

- placing at least one further electrode in the soil at a distance from said electrodes;
- measuring voltage drop information indicative of a voltage drop along a path through the soil starting from said further electrode;
- using the voltage drop information to remove at least part of an effect of soil resistivity on the overall resistance information on said detecting.

4. A method according to Claim 1, comprising

- placing a plurality of further electrodes in the soil, each at a distance from a respective electrode but closer to said respective electrode than any one of the other electrodes anodes said electrodes;
- measuring a voltage drop from each of the further electrodes to its respective electrode;
- determining the information indicative of electrical resistances from the measured voltage drops.

5. A method according to Claim 1, wherein the information indicative of electrical resistances of paths into the soil from surfaces of respective ones of the electrodes is obtained for respective ones or sub-groups of the electrodes individually; the current being cut down only in a particular electrode or group, in response to detection of said increase in resistance in the path from the particular electrode or sub-group, .

6. A method according to Claim 1, wherein the electrodes include anodes and cathodes placed interspersed with one another in the soil, the method comprising
- circulating liquid containing acid and/or another complexing agent around the surface of the cathodes;
- obtaining said information indicative of electrical resistances of paths into the soil from surfaces of respective ones of the cathodes;
- temporarily cutting down electrical current at least through a particular cathode in the path from which an increase of the electrical resistance is detected, to a stepped down level, in response to said detection.

7. A method according to Claim 6, wherein the current is cut down for a predetermined time interval.

8. A method according to Claim 7, wherein the predetermined time interval has a duration of between five minutes and two hours.

9. A method according to Claim 6, wherein the current to the particular cathode is cut down substantially to zero.

10. A method according to Claim 6, wherein the current through a particular anode that is placed closest to the particular cathode is stepped down to cut down the current through the particular cathode.

11. A method according to Claim 6, wherein the current through individual anodes and/or cathodes is controlled to maintain a regulated average level, independent of soil resistivity, while not cut down.

12. A method according to Claim 11, wherein the set level substantially equals an equilibrium level at which a rate of formation of hydroxyl ions due to the current is in equilibrium with a rate of removal of the hydroxyl ions by acid from the circulating liquid.

13. A method according to Claim 11, wherein the stepped down level is substantially below the equilibrium level.

14. A method of in situ electroremediation of soil material, in a land area where there is a groundwater flow, the method comprising

- placing a plurality of first and second electrodes in the soil at respective positions in a land area, the first and second electrodes alternating along a line that extends transverse to a direction of the groundwater flow;
- driving electric voltages differences between first and second electrodes;
- measuring flow speed information about a groundwater flow speed;
- lowering and increasing the voltage differences in response reductions and increases in the measured flow speed respectively, so that the voltage difference remains sufficient to attract substantially all of a contaminant to reach the first or second electrodes.

15. A method according to Claim 14, comprising

- determining a set value for an electric field in the soil for the measured flow speed;
- providing at least one sensing electrode in the soil;
- measuring a voltage drop from said sensing electrodes;
- regulating the voltage differences so that the voltage drop corresponds to the set value of the electric field.

16. A method of in situ electroremediation of soil material, in a land area where there is a groundwater flow, the method comprising
- placing a plurality of first and second electrodes in the soil at respective positions in a land area, the first and second electrodes alternating along a line that extends transverse to a direction of the groundwater flow;
- placing one or more nutrient infiltration filters along said line;
- regulating currents between first and second electrodes;
- measuring flow speed information about a groundwater flow speed;
- lowering and increasing a level of said current in response reductions and increases in the measured flow speed respectively, so that the current remains sufficient to spread a predetermined concentration of nutrients into the groundwater flow..

17. A method according to Claim 16, comprising limiting an electric field between the electrodes to above a level that is selected dependent on the ground water flow speed.

18. A method of in situ electroremediation of soil material, the method comprising
- placing a plurality of electrodes in the soil at respective positions in a land area;
- repeatedly sowing and harvesting plants in the land area;
- supplying electric current through the electrodes between sowing and harvesting;
- repeatedly reversing a polarity of current between the electrodes;
- measuring information indicative of cumulative charge passed through respective ones of the electrodes following a reversal of polarity;
- selecting a time point when the polarity is reversed dependent on the cumulative charge when the measured cumulative charge reaches a predetermined threshold value.

19. A method of in situ electroremediation of soil material, the method comprising

- placing a plurality of electrodes in the soil at respective positions in a land area;
- supplying electric current through the electrodes;
- regulating a power dissipated in the soil by adjustment of a duty cycle with which current is delivered to the electrodes, the duty cycle comprising periods of at least thirty seconds during which no current is supplied.

20. A system for performing in situ electroremediation of soil material, the system comprising

- a plurality of electrodes in the soil at respective positions in a land area;
- an electric power supply source coupled to supply electric current through the electrodes;
- a control circuit arranged to monitor information indicative of electrical resistances of paths into the soil from surfaces of respective ones of the electrodes, to detect increases of the electrical resistances and to temporarily cut down electrical current from the electric power supply source at least through a particular electrode in the path from which an increase of the electrical resistance is detected, to a stepped down level, in response to detection of said increase.

21. A system according to Claim 20, wherein opposite poles of the electric power supply source are coupled to a first and second group of electrodes respectively, the system comprising sensors coupled to respective connections between the electric power supply source and respective ones of the electrodes, the sensors being arranged to provide the control circuit with information indicative of respective current-voltage ratio's, each between a current through a respective electrode from the first group and a voltage difference between the respective electrode from the first group and one or more electrodes from the second group, the control circuit deriving the information indicative of electrical resistances for each respective electrode from the respective current-voltage ratio for that respective electrode.

22. A system according to Claim 21, wherein the control circuit is arranged to eliminating at least part of an effect of soil resistivity on the information indicative of respective current-voltage ratio's on the detection of the increases.

23. A system according to Claim 22, comprising

- at least one further electrode in the soil at a distance from said electrodes, the further electrode coupled to the control circuit;
- the control circuit being arranged to obtain voltage drop information indicative of a voltage drop through the soil along a path starting from said further electrode and to use the voltage drop information to eliminate at least part of an effect of soil resistivity on the information indicative of respective current-voltage ratio's on the detection of the increases.

24. A system according to Claim 20, comprising

- a plurality of further electrodes in the soil, each at a distance from a respective electrode but closer to said respective electrode than any one of the other electrodes anodes said electrodes, the further electrode being coupled to the control circuit;
- the control circuit being arranged to obtain the information indicative of the electrical resistances from information indicative of voltage drops from the further electrodes to their respective electrodes.

25. A system according to Claim 20, wherein the information indicative of electrical resistances of paths into the soil from surfaces of respective ones of the electrodes is monitored for the respective ones of the electrodes individually; the current being cut down selectively through a particular electrode in the path from which an increase of the electrical resistance is individually detected, to a stepped down level, in response to said increase.

26. A system according to Claim 20, wherein the electrodes include anodes and cathodes placed interspersed with one another in the soil, the system comprising

- a liquid circulation sub-system arranged to circulate liquid containing acid and/or other complexing agents around the surface of the cathodes;
- the control circuit monitoring said information indicative of electrical resistances of paths into the soil from surfaces of respective ones of the cathodes, and temporarily cutting down electrical current at least through a particular cathode in the path from which an increase of the electrical resistance is detected, to a stepped down level, in response to said increase.

27. A system according to Claim 26, wherein the current is cut down for a predetermined time interval.

28. A system according to Claim 27, wherein the predetermined time interval has a duration of between five minutes and two hours

29. A system according to Claim 26, wherein the current to the particular cathode is cut down substantially to zero.

30. A system according to Claim 26, wherein the current through a particular anode that is placed closest to the particular cathode is stepped down to cut down the current through the particular cathode.

31. A system according to Claim 6, wherein the current through individual anodes and/or cathodes is controlled to maintain a regulated average level, independent of soil resistivity, while not cut down.

32. A system according to Claim 31, wherein the set level substantially equals an equilibrium level at which a rate of formation of hydroxyl ions due to the current is in equilibrium with a rate of removal of the hydroxyl ions by acid from the circulating liquid.

33. A system according to Claim 32, wherein the stepped down level is substantially below the equilibrium level.

34. A system for in situ electroremediation of soil material, in a land area where there is a groundwater flow, the system comprising
- a plurality of first and second electrodes placed in the soil at respective positions in a land area, the first and second electrodes alternating along a line that extends transverse to a direction of the groundwater flow;

- an electric voltage supply source coupled to apply a voltage difference between the first and second electrodes;
- a sensor for measuring information about a groundwater flow speed;
- a control circuit comprising programmed information that relates groundwater flow speed to electric field values, the control circuit being arranged to set the a level of the voltage difference dependent on the information about a groundwater flow speed according to the programmed information.

35. A system according to Claim 34, comprising a further electrode for measuring information about voltage drop through the soil from said further electrode, the control circuit being arranged to regulate the voltage difference so that the voltage drop corresponds to the electric field required by the programmed information.

36. A system for in situ electroremediation of soil material, in a land area where there is a groundwater flow, the system comprising
- a plurality of first and second electrodes placed in the soil at respective positions in a land area, the first and second electrodes alternating along a line that extends transverse to a direction of the groundwater flow;
- an electric voltage supply source coupled to supply regulated currents from respective first electrodes to the second electrodes;
- a sensor for measuring information about a groundwater flow speed;
- a control circuit comprising programmed information that relates groundwater flow speed to current levels, the control circuit being arranged to set the a levels of the currents from the first electrodes dependent on the information about a groundwater flow speed according to the programmed information.

37. A system according to Claim 36, wherein the control circuit is arranged to overrule current regulation to limit a lower bound on an electric field strength in the soil between the electrodes.

38. A system for in situ electroremediation of soil material, the system comprising

- a plurality of electrodes in the soil at respective positions in a land area;
- an electric supply source arranged to supply current through the electrodes;
- a polarity setting circuit for setting a polarity of current between the electrodes;
- a control circuit arranged to monitor information indicative of cumulative charge passed through respective ones of the electrodes following a reversal of the polarity and to select a time point whereat the polarity setting circuit is controlled to reverse the polarity, the time point being selected dependent on the cumulative charge, at a time point when the cumulative charge reaches a predetermined threshold value.

39. A system for in situ electroremediation of soil material, the system comprising

- a plurality of electrodes in the soil at respective positions in a land area;
- an electric power supply source for supplying current through the electrodes;
- a power regulating circuit for regulating power dissipated in the soil by adjustment of a duty cycle with which current from the electric power supply source is delivered to the electrodes, the duty cycle comprising periods of at least thirty seconds during which no current is supplied.

40. An apparatus for controlling current and/or voltage supplied to first and second electrodes that have been inserted in a land area for in situ electroremediation of soil material, the apparatus comprising

- connections for the first and second electrodes;
- an electric power supply source coupled between the first and second electrodes;
- a control circuit arranged to monitor information indicative of electrical resistances of paths into the soil from surfaces of respective ones of the electrodes, to detect increases of the electrical resistances and to temporarily cut down electrical current from the electric power supply source at least

through a particular electrode in the path from which an increase of the electrical resistance is detected, to a stepped down level, in response to said detection.

41. An apparatus for controlling current and/or voltage supplied to first and second electrodes that have been inserted in a land area for in situ electroremediation of soil material, the apparatus comprising

- connections for the first and second electrodes;
- an electric power supply source with a first and second terminal;
- switching circuits coupled between the first terminal and respective ones or sub-groups of the first electrodes, the second electrodes being coupled to the second terminals;
- a current regulation circuit arranged to control average currents through respective ones of the electrodes by adapting duty cycles with which the switching circuits conductively connect the first terminal to the respective ones or sub-groups of the first electrodes.

42. An apparatus according to Claim 41, comprising a control circuit arranged to monitor information indicative of electrical resistances of paths into the soil from surfaces of respective ones of the electrodes, to detect increase in the electrical resistances and to temporarily cut down electrical current from the electric power supply source at least through a particular first or second electrode in the path from which an increase of the electrical resistance is detected, to a stepped down level, in response to said detection.

43. An apparatus according to Claim 40, comprising further switching circuits coupled between the second terminal and respective one or sub-groups of the second connections, the control circuit being arranged to cut down the electrical current from the electric power supply source through a particular second electrode by making a particular further switching circuit between the second terminal and the particular electrode non-conductive.

44. An apparatus according to Claim 40, wherein the control circuit is arranged to cut down the cut down electrical current from the electric power

supply source through a particular first or second electrode by reducing the duty cycle for a one or more selected ones of the first connections.

45. An apparatus according to Claim 40, the control circuit being arranged to determine the information indicative of the electrical resistance from an average voltage between the particular first or second electrode and one or more second or first electrodes.

46. An apparatus according to Claim 40, comprising current sensors coupled to respective ones of sub-groups of the second connections, for measuring current information indicative of current sizes through respective ones of sub-groups of the second connections, the current sensors having outputs coupled to the control circuit, the control circuit being arranged to determine the information indicative of the electrical resistance using information about the current information and an average voltage between the particular first or second electrode and one or more second or first electrodes.

47. An apparatus according to Claim 40 comprising a connection for a further electrode, the control circuit being arranged to determine the information indicative of the electrical resistance using information about the a total resistance between first and second electrodes and to use information about a voltage drop from the further electrode to substantially eliminate ???? eliminating an effect of soil resistivity on said detection.

48. An apparatus according to Claim 40 the control circuit having an input for connecting a sensor for groundwater flow speed information, the control circuit comprising a memory for storing programmed information associating groundwater flow speed and voltage difference values, the control circuit being switchable to a mode in which the current regulation circuit is set to provide a current selected dependent on the ground water flow speed information, as associated with the water flow speed according programmed information.

49. An apparatus according to Claim 40 the control circuit having an input for connecting a sensor for groundwater flow speed information, the

control circuit comprising a memory for storing programmed information associating groundwater flow speed and voltage difference values, the control circuit being switchable to a mode in which the current regulation circuit is disabled, the control circuit controlling the duty cycle to realize a voltage selected dependent on the ground water flow speed information, as associated with the water flow speed according programmed information.

50. An apparatus according to Claim 40, wherein the electric power supply source is an AC source, the control circuit being switchable to a mode in which the current regulation circuit is disabled, the control circuit being arranged to make the switching circuits pass current from the AC source of a selected polarity only, the control circuit inverting the polarity at time points selected dependent on an accumulated amount of charge passed by the electrodes.